Supplementary value of functional imaging in forensic medicine

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Abstract

Aim: The aim of this study is to evaluate the role of functional imaging for forensic purposes.
Methods: We reviewed a few outpatient cases that were sent to our department for examination after traumatic events and one case with neuropsychic disturbances
Results: Functional imaging showed signs of traumatic lesions in the skeletal system, of brain metabolism and of renal failure.
Conclusion: Functional disturbances following traumatic events are in some cases more important than morphological abnormalities. Targeted scintigraphic examinations could be applied for visualisation of traumatic lesions or evaluation of functional disturbances caused by traumatic events. These examinations can be used as evidence in the courtroom.

Key words: forensic medicine, functional imaging, scintigraphy

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Introduction

Traumatic lesions are often blunt or have internal manifestations which might be overseen by clinical examination. Morphological investigation as by x-ray, sonography or computed tomography (CT) are often used for evaluation of these cases. However, these anatomical imaging methods may fail to delineate injuries, as has been shown in cases of bone lesions.[1,2] The supplementary role of functional imaging by nuclear medicine investigations has been demonstrated in the vast field of clinical medicine, and nuclear medicine has become a routine examination in different pathologies. There are some case reports reflecting the possible use of nuclear medicine in forensic medicine. However, the majority of these cases are focused on brain imaging[3-5] with a few reports on bone[6,7] and renal scintigraphy. Because of the toxicities associated with the agents used, the limitation of contrast enhanced computerized tomography and magnetic resonance imaging has been discussed, particularly in the case of renal injury.[8]

In this study we aim to demonstrate the added value of functional imaging after different injuries, which could have a forensic application.

Patients and methods

We reviewed retrospectively the cases of

Table 1. *Patient characteristics.*

Case Nr.	Gender, Age	Short history	Functional imaging
1	M, 34 y	corporal mistreatment	Brain PET
2	F, 55 y	memory disturbances	Brain PET
3	M,23 y	anosmia	Brain SPECT
4	M, 59 y	prostate cancer, scapula fracture	Bone scan
5	M, 30 y	corporal mistreatment	Bone scan
6	M, 36 y	physical attack	Bone scan
7	F, 68 y	car accident, suspected rib fracture	Bone scan
8	M, 31 y	bike accident, suspected renal trauma	Renal scan

functional imaging of different patients with a history of physical trauma prior to the scintigraphic investigation who were sent to our department for different examinations. Table 1 shows the patient characteristics.

The examinations were performed on an EXACT PET (positron emission tomography) scanner (Siemens) or SPECT (single photon emission computed tomography)-CT camera (Symbia T6, Siemens). The attenuation correction was made using a Cs137 point source for the PET scanner and a low-dose CT for the gamma camera (20 mAs, 130 kV).

Results

Neuroimaging

Case 1

A 34-year-old Russian male was beaten with a metal bar on the head on the right frontal area five years prior to examination. He suffered from partial retrograde amnesia, headaches, fatigue and sleep disturbances. An out-of-house CT examination revealed gliotic changes right frontal and temporal with possible haemosiderin depositions.

We performed a ^{18}F-FDG-PET of the brain after i.v. injection of 320 MBq ^{18}F-FDG; the patient's blood glucose level was 84 mg/dl. The examination procedure was according to our protocol as described earlier.[9] The analysis was performed both visually and voxel-based using Cortex ID (Advantage Workstation, GE). The examination revealed a severe hypometabolism right frontal basal (Figure 1) and a slight hypometablism left occipital, indicating a possible contre-coup effect. The functional disturbance imaged by PET and the possible metabolic sign of a contre-coup effect in connection with the previous head injury were more distinctive than morphological finding by CT.

Case 2

A 55-year-old female was sent for ^{18}F-FDG-PET of the brain. She wondered why she had been sent for the examination, because she felt herself to be healthy. According to the history provided by family members,

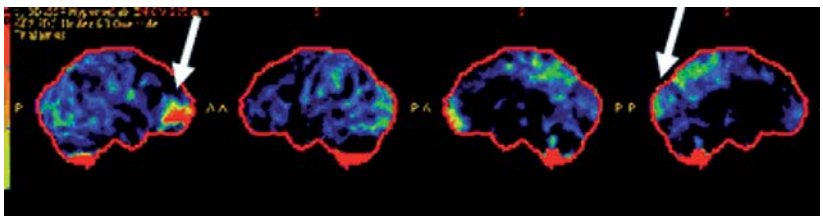
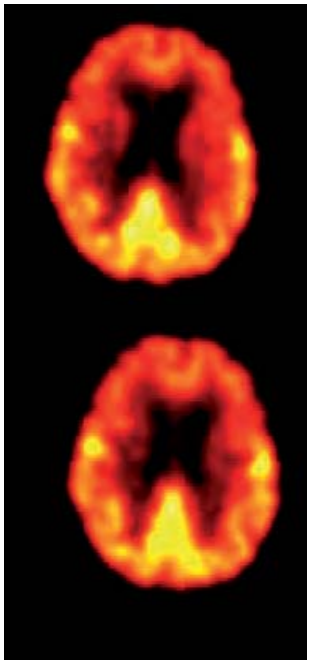
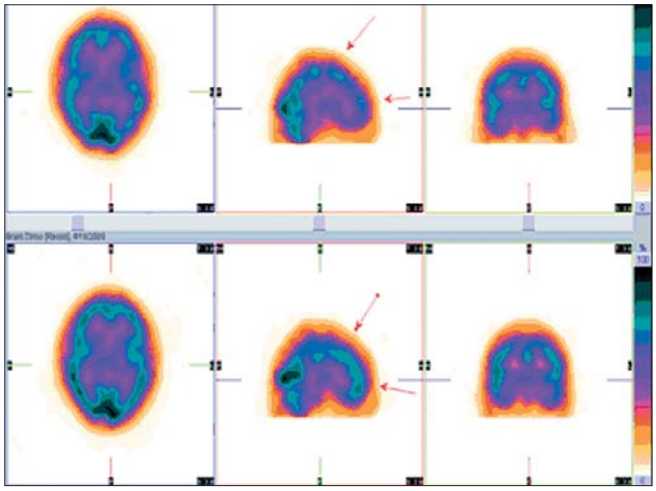


Figure 1. *FDG-PET of case nr. 1.*



◀ **Figure 2.** *FDG-PET of case nr. 2.*



▲ **Figure 3.** *Brain perfusion SPECT of case nr. 3. The upper row shows baseline images and the lower row shows post-stimulation images after olfactory stimulation by vanilla showing increased radiotracer uptake after stimulation.*

she had developed an extravagant spending pattern during the last 1½ years. A manic-depressive disorder or neuropsychologic disorder was suspected. MRT revealed signs of brain atrophy with enlargement of inner and outer liquor spaces. Metabolic investigation by ^{18}F-FDG-PET revealed marked hypometabolism frontal on both sides (Figure 2), which led to the final dignosis of frontotemporal dementia. The severe metabolic impairment detected could have juridical impact in a legal case, especially in a situation such as this, involving enormous financial expenditures by the patient.

Case 3

A 23-year-old man had a car accident with minor head trauma and no loss of consciousness. He claimed in court that he became anosmic after the accident and asked for compensation. According to Islamic law, anosmia entitles the injured party to half the maximum monetary penalty (so called complete blood money). The butanol test was negative and the coffee test was reported as bitter. A brain CT scan and MRI were normal. The forensic medicine specialist in court asked for functional imaging to prove or disprove the claim. SPECT imaging was done after i.v. injection of 20mCi of ^{99m}Tc ECD at baseline and after olfactory stimulation with vanilla. The post-stimulation images (Figure 3) showed increased perfusion in the left orbitofrontal and parietal regions compared to the baseline scan. The claim was rejected.

Skeletal Scintigraphy

Case 4

A 59-year-old male with a history of prostate cancer was referred to bone scintigraphy because of elevated PSA levels. The bone

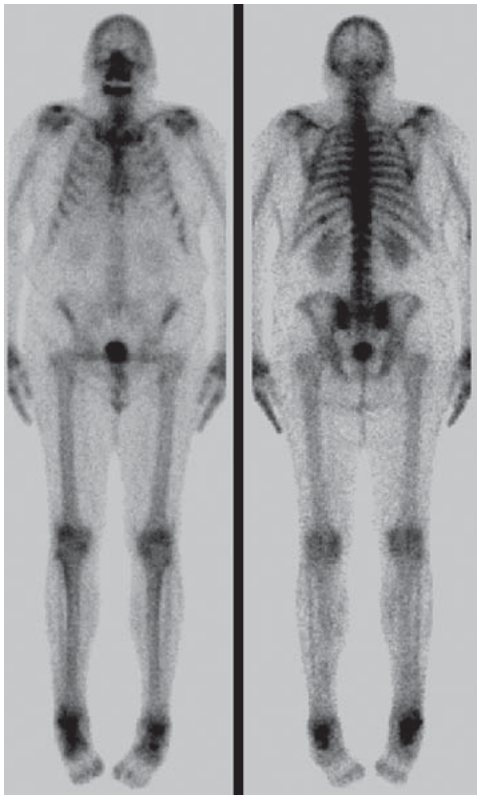


Figure 4. *Bone scintigraphy. Case nr. 4.*

scintigraphy was performed 3 hours after i.v. injection of ^{99m}Tc MDP. The images showed a focal slightly enhanced uptake in the 10th rib left dorsal. This was the only bone lesion detected. The osteoblastic activity correlated with a fracture in this area suffered seven years earlier (Figure 4).

This case demonstrates the possible role of bone scintigraphy for detection, even years after trauma, of old injuries of the ribs, which may be difficult to be diagnosed by conventional X-ray. X-ray was not performed additionally, since no consequences for the cancer therapy were expected.

Case 5

Bone scintigraphy of a 30-year-old male patient from the Middle East who alleged corporeal mistreatment 3 years earlier. The bone scan shows areas with enhanced bone metabolism in the left temporal region (Figure 5a), in distal part of the right fibula; the latter lesion was better visualized in the additional SPECT-CT images, where additional signs of an old fracture were seen in the low-dose CT images (Figure 5b). These lesions could correlate with the history of physical trauma in this case as published earlier.[1] Additional lesions in the left foot in the subchondral area of the tibia and left navicular bone (not shown here) are less likely to be caused by degenerative disease and rather to be interpreted as posttraumatic evidence, especially considering the young age of the patient.

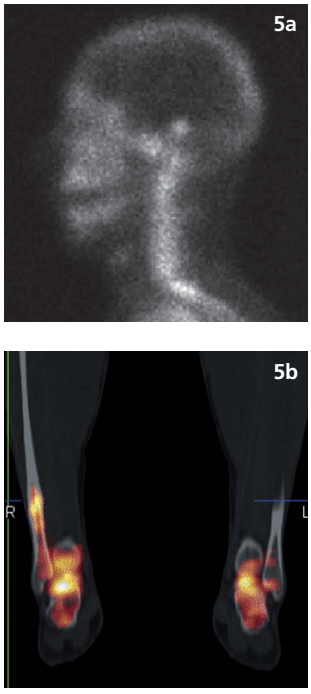


Figure 5 (a and b). *Bone Scintigraphy. Case nr. 5.*

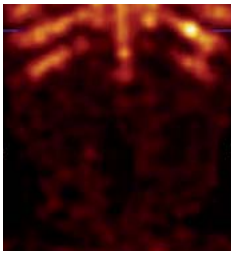
Case 6

A 36-year-old male was attacked by another person and fell to the floor. Conventional X-ray was inconclusive. The patient suffered from back pain. He was sent six months later for bone scintigraphy. We performed a bone scan with additional SPECT-CT (low dose CT, Symbia T6, Siemens) of the lower back. The examination revealed enhanced osteoblastic activity in the 10th rib left dorsal and in the processus transversus of the 1st lumbar vertebra on the left side (Figure 6a). The low dose CT revealed a small fracture of the processus transversus of L1 and no radiological lesion in the 10th rib. Hence, both osteoblastic lesions could be interpreted as posttraumatic. However, the testimony of a physician in the courtroom expressed the opinion of an old sport injury. Recently, two years later (still ongoing process), we performed a second bone scintigraphy; the lesion in the 10th rib is still visible (Figure 6b1), although less remarkable then in the first examination, whereas the scintigraphic lesion and the fracture seen in the low dose CT of L1 appear as already healed (Figure 6b2).

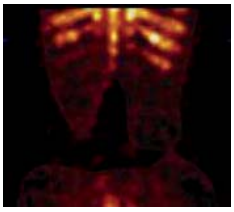
We concluded that both lesions at the time of the first examination were recent at that time and have largely healed at the second examination two years later.

Case 7

A 68-year-old female after a car accident one month earlier complained of chest and back pain on the right side. Radiography of the chest and ribs was normal. For damage compensation, the court needed to know whether there were rib fractures. The forensic medicine specialist requested a bone scan. The scan (Figure 7) showed increased uptake in the lateral portion of the right 6th–8th rib consistent with rib fracture.



6a1.



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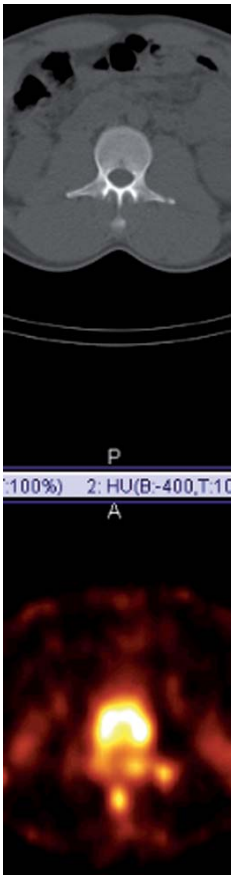

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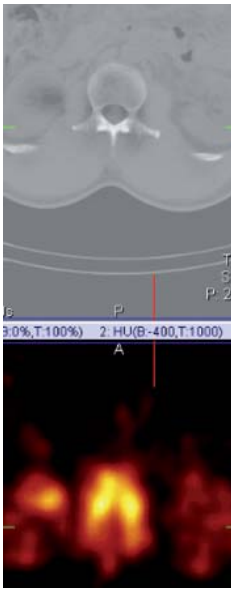

6b2.

Figure 6. *Bone scintigraphy. Case nr. 6.*

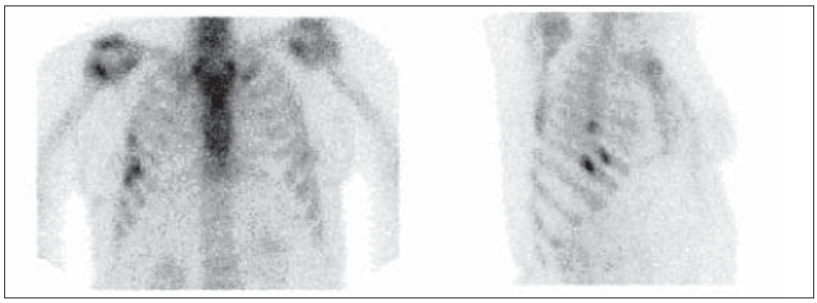

Figure 7. *Bone scintigraphy. Case nr. 7.*

Renal Scintigraphy

Case 8

A 31-year-old male had a bicycle accident with blunt abdominal trauma three weeks prior to his referral to our department. The renal planar and SPECT image by ^{99m}Tc DMSA showed horseshoe kidneys with a large parenchymal defect caused by the accident in the left renal cortex (Figure 8). The functional scintigraphy with ^{99m}Tc MAG-3 demonstrated an almost isosthenuric curve. Both examinations showed that the extent of the renal damage was dramatic. Ultrasonography showed primarily an enlarged renal pelvis on the left side.

CT with contrast media was not possible, because of the danger of a possible leak (although it was not seen in scintigraphy).

Functional renal scintigraphy showed in this case the extent of the damage to the left kidney.

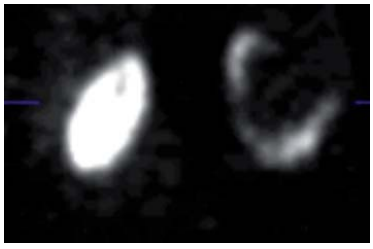

Figure 8. *Case nr. 8.*

Discussion

Forensic investigations with radiographic examinations are already undertaken in many centres.[10-12] In some cases functional imaging can provide more insight regarding the extent of the traumatic lesions and their functional consequences, as demonstrated in our cases in brain and renal imaging. In a previous study, Piskunowicz et al. emphasized the potential role of radionuclide cerebral blood flow studies in forensic medicine and criticized the under-utilization of the method at that time.[13] The same group emphasized in a following publication that the results of functional imaging should be interpreted together with such other findings as psychometric tests and other neuroimaging methods,[14] a procedure which was equally recommended by other authors.[15] In a recent paper the case of a sexual assault was presented. The defendant underwent a PET scan to clarify whether he was able to have planned the crime. Because of frontal hypofunction the involved psychiatrist indicated that the defendant could not have been able to plan the assault.[16]

Anosmia following head trauma may present a forensic issue with an important legal impact, especially in Islamic countries with Sharia law. Few studies have been published assessing the validity of brain SPECT before and after olfactory stimulation.[17] Although the findings are nonspecific, it can

help in detection of patients with anosmia after brain trauma.

We have shown that some nuclear medicine investigations, such as brain imaging and bone and renal scintigraphy may have additional impact in the evaluation of traumatic lesions and their functional consequences and could be applied more frequently in forensic cases.

Functional imaging often has a high sensitivity, since metabolic changes are most probably existent before morphological changes can be visualized by anatomical imaging. However, one should be aware of the low specificity of the metabolic imaging and this should be taken into consideration particularly in forensic cases. Therefore, taking an exact history should be of central importance in forensic issues and functional imaging can then be an auxiliary measure for further appraisal of the case.

Conclusion

Functional disturbances following traumatic events can be in some cases more important than morphological abnormalities. Targeted scintigraphic examinations can be applied for visualisation of traumatic lesions or evaluation of functional disturbances caused by traumatic events. These examinations can have forensic impact and be entered as evidence in the courtroom in addition to conventional radiological imaging.

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